EFFECTS OF WORD ORTHOGRAPHY AND CONCRETENESS ON CEREBRAL HEMISPHERIC ASYMMETRY IN KOREAN BILINGUALS

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1988

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Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of
the Requirements for the Degree of Doctor of Philosophy

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April, 1988

Chairman: Ira Fischler
Major Department: Psychology

The main purpose of this research was to investigate how different orthographies for representing the words of a language in writing might be associated with different patterns of hemispheric asymmetry. In the first experiment, 24 English-speaking monolinguals decided whether a series of common, high-frequency words presented to the left visual field (LVF) or to the right visual field (RVF) were concrete (e.g., milk) or abstract (e.g., fate). A significant advantage in response latency was observed for RVF presentation, indicating a left hemisphere (LH) superiority, consistent with prior findings. Concrete words were associated with somewhat smaller field asymmetry in each of the four trial blocks, although the trend did not reach significance.

Experiment 2 demonstrated that different orthographies can reverse the laterality pattern. In a within-subject design, 24 Korean-English bilinguals performed the same task as in Experiment 1 for three types of scripts. In three blocks of trials, the words were given in English, in Korean with Hangul script, or in Korean with Chinese script.

A RVF-LH advantage was found for both Hangul and English but there was a clear LVF-RH superiority for Chinese script. This striking reversal was observed both for single-character and double-character Korean words (corresponding to one and two syllables). Since Chinese script is ideographic with no phonetic cues within a word-character while Hangul and English do have within-word phonetic cues, the results support the hypothesis of LH superiority in phonological analysis, and RH superiority in visuospatial processing, within a linguistic task.

The interaction between concreteness and visual half field was highly significant for Hangul and English and marginal for Chinese. In all cases, abstract words showed greater asymmetry than did concrete words. This result is in general consistent with the hypothesis that lexical information about concrete words is represented more bilaterally. The asymmetry for English words for monolingual subjects in Experiment 1 and Korean bilinguals in Experiment 2 was very similar despite tremendous differences in their language acquisition histories.

CHAPTER I

INTRODUCTION

Language Lateralization in Monolinguals

Ever since Paul Broca suggested that the two cerebral hemispheres of the brain might subsume different kinds of functions, and for some of those functions one hemisphere is dominant over the other (cerebral dominance), the concept of lateralization has provoked a variety of fascinating questions for both clinical and experimental research. But the pattern of cerebral dominance of language has attracted more attention from these researchers than any of the other questions.

Cerebral dominance for language is a concept which posits that our verbal skills are not equally distributed between the two hemispheres. It is based on a wide range of evidence that the left hemisphere is specialized for language comprehension and production, while the right hemisphere is specialized for the processing of nonverbal, visuospatial aspects of stimuli.

This view of left hemisphere dominance for language has been broadly supported by evidence from both clinical and experimental studies using a wide range of methodologies. Clinical studies have exploited methodologies such as commissurotomy (Gazzaniga, 1970; Levy, Trevarthen, & Sperry, 1972; Zaidel, 1978a), unilateral lesions (Geschwind, 1972, 1979; Milner, 1974), hemispherectomy (Dennis & Whitaker, 1977; Whitaker & Ojemann, 1977), cerebral regional blood flow (Risberg, Halsey, Wills, & Wilson, 1975; Wood, 1980), neuroanatomy (Galaburda, LeMay, Kemper, & Geschwind, 1978; Geschwind & Levitsky, 1968), electric stimulation (Ojemann & Mateer, 1979; Penfield & Jasper, 1954; Penfield & Roberts, 1959), injection of sodium amytal (Wada & Rasmussen, 1960), and Positron Emission Tomography (PET scan) (Gur, Gur, Rosen, Warach, Alavi, Greenberg, & Reivich, 1983).

Many of the decisive findings about the dominance of linguistic capability of the left hemisphere have come from clinical studies. However, the discovery that with appropriate techniques one can detect hemispheric asymmetry has led to a plethora of behavioral studies. Studies of normal subjects in experimental setting have used research methods such as tachistoscopic visual half-field presentation (Bradshaw & Gates, 1978; Moscovitch, 1972; Pirozollo, 1977), dichotic listening (Kimura, 1961;

Lambert & Beaumont, 1982), lateral eye movement (Bakan, 1969; Day, 1964), dichhaptic testing (Benton, Levin, & Varney, 1973; Nilsson, Glencross, & Geffen, 1980; Witelson, 1974), perceptual-motor psychometric tests (Loye, 1982; Torrance & Reynolds, 1980; Wonder & Donovan, 1984).

These studies of cerebral specialization of linguistic and nonlinguistic functions have repeatedly suggested that the roles of the left and the right hemisphere may be more intertwined than was first believed, although a simple dichotomous explanation of laterality still often prevails. However, just as no single factor can adequately describe the nature of intelligence, no single dichotomy has fully described cerebral asymmetry properly. Table 1 summarizes some of the dichotomous terms that have been used to describe the mode of processing by two cerebral hemispheres (Bogen, 1969). This table suggests that cerebral dominance is a multifactorial process and provides a conceptual framework for further discussion.

Table 1

Terms for Left and Right Mode Hemispheric Processing

Author	Left hemisphere	Right hemisphere
Bogen	propositional	appositional
Bogen & Gazzaniga	verbal	visuospatial
Bruner	rational	metaphoric
Freud	secondary process	primary process
Goldstein	abstract	concrete
Jackson	expression	perception
Levy-Agresti & Sperry	logical analytic	synthetic perceptual
Milner	verbal	non-verbal
Price	analytic	synthetic

Note Adapted from "The other side of the brain II: An appositional mind" by J. Bogen, 1969. Bulletin of the Los Angeles Neurological Societies, 34, 135-162.

The word "dominance" could also be very misleading because it gives an impression that one hemisphere dominates the other and the dominant one is a major hemisphere and the subdominant one is a minor one. In fact, the hemispheres are more cooperative and coordinating in their functioning than mutually exclusive, dominant and competitive.

An example from research on the perception of speech illuminates this coordination. It is known that the left hemisphere is superior to the right hemisphere when the task requires a processing or detection of changes in a signal over brief time intervals (Efron, 1963; Mills and Rollman, 1979). This is what is required for phonemic discrimination when acoustic signals are being modified (i.e., speech sounds in conversation) over the intervals of the order of hundredths of a second. Conversely, the right hemisphere is superior in recognizing aspects of intonation, melody, and timbre particular to each individual speaker that do not require analysis of the signal's phonetic composition (Ardila and Ostrosky-Solis, 1984).

This tells us that cerebral asymmetry in linguistic function does not necessarily mean that the "dominant" hemisphere (LH) is superior to the other (RH) in all language fuctions. Therefore, it needs to be stressed that hemispheric specialization in language refers to specialization in recognizing certain information parameters and controlling certain aspects of linguistic behavior rather than to the specialized recognition and processing of linguistic information as a whole.

Support for this assertion comes also from studies of aphasic patients. Patients with left hemisphere lesions sometimes retain linguistic functions, especially semantic ones. People with deep dyslexia (e.g., patients who are unable to read orthographically regular nonwords, such as gake or frone due to the lack of the ability to access the phonological rules for pronouncing words) as a result of left hemisphere lesions are phonetically impaired but have less trouble extracting meaning from script (e.g., choosing objects or responding to instruction).

Studies on individuals who have undergone commissurotomy also suggest that the right hemisphere has its own lexicon (Gazzaniga, 1970; Levy, Trevarthen, & Sperry, 1972; Zaidel, 1978). By surgically severing the corpus callosum and leaving the cerebral hemispheres functionally independent, one can observe the fate of linguistic information presented to one hemisphere without the other participating.

Such patients could recognize simple, high-frequency words (nouns but not verbs) presented to their left field of vision with their left hand although they could not verbalize them. Subjects also could show autonomous emotional reactions. For example, when the stimulus word with some emotional content is flashed to their left visual field, they could experience the proper emotional reaction, even though they could not verbalize the reason for doing so because the left hemisphere, which mediates speech, does not know the reason for the response.

The degree of the right hemisphere's language capability is still controversial. A review of experimental studies (Searleman, 1977) suggests that the lack of convincing evidence of the right hemisphere's involvement in language processing may be due to such problems as the lack of consensus about a theoretical framework, variability in methodological paradigms and difficulties in controlling experimental variables.

Lateralization in Bilinguals

There has been renewed interest in polyglot aphasias, but it is only very recently that researchers have begun to show an interest in hemispheric specialization of languages among normal bilinguals (Vaid & Genesee, 1980). However, both clinical and experimental studies suggest that lateralization for bilinguals may differ from that of monolinguals, and that within bilinguals, their different competence in more than one language may lateralize differently (see Galloway, 1982; Vaid, 1983 for reviews).

Since the question of neuropsychological repercussions of bilingualism has been neglected for so long, the evidence on brain organization of bilingual language function is far from conclusive (Vaid & Genesee, 1980). So far, the research on cerebral lateralization of bilinguals, especially the role and the ability of the right hemisphere, has provided equivocal results. Some studies report differences, either in the direction of greater right hemisphere involvement (Obler, Albert, & Gordon, 1975; Hardyck, 1980; Sussman, Franklin, & Simon, 1982) or greater left hemisphere involvement (Carroll, 1980; Gordon, 1980; Gordon & Zatorre, 1981; Soarez, 1982) while others (Galloway & Scarcella, 1982; Piazza & Zatorre, 1981) found no differences in the lateralization pattern for one or both of the languages spoken by bilinguals.

Given that the pattern of laterality for monolinguals could vary widely depending upon the type of task, materials or subjects (e.g., age, gender, handedness), similar complications might be expected in bilingual laterality studies. Obler, Zatorre, Galloway, and Vaid (1982) have summarized numerous experimental variables of potential importance in studies of bilingual laterality into four major categories: subject selection (handedness, age, gender, level of proficiency, age, manner and environment of second language acquisition), language stimuli (word length, frequency, grammatical class, concreteness, phonetic composition), testing procedures (technical issues, task differences, practice effect, monolingual control), and analysis (measurement and reliability, continuous vs. discrete laterality effects, etc). Since many of these factors vary across studies, it is not surprising that inconsistent patterns of lateralization are often reported.

Orthography and Lateralization

In laterality studies among bilinguals, the main debate has been centered on the question of the extent of right hemisphere participation in the processing of each of their languages as contrasted to monolinguals. An alternative approach which provides better control at least for linguistic and conceptual variables is the study of people with two written versions (scripts) or orthographies for one spoken language.

Recently, there has been some work comparing hemispheric specialization of language for such subjects, mainly Japanese natives (see Hung & Tzeng, 1981; Paradis, Hagiwara, & Hildebrandt, 1985; Vaid, 1983 for reviews). Written Japanese is composed of two distinct orthographies: kanji, the ideographic script derived from Chinese, and kana, the syllabic script, which is a "regular" script in the sense that each character has an invariant pronunciation; each character corresponds to a syllable (Morton & Sasanuma, 1984; Sasanuma, 1980). Kanji characters are most frequently used for content words. In fact, almost all nouns are written in kanji, while kana characters are for grammatical morphemes, and for foreign loan words.

By examining the language laterality of biscriptual people who have also learned a foreign language (e.g., English), one can have both cross (e.g., kana vs. English) and within (e.g., kanji vs. kana) language comparisons with the same group of speakers.

Script and Ethnicity

However, even the studies using biscriptual subjects could not control some of the critical variables that might influence the language processing of the two hemispheres. It is worth contrasting some of the critical differences between the two writing systems (the Japanese and the Korean) that are of interest in this study.

Specifically, due to the intrinsic differences between kanji and kana script, a kana transcription usually consists of more characters than its kanji counterpart. Since it is still uncertain as to how the different number of Chinese or kanji symbols would affect the pattern of lateralization (Hatta, 1978; Tzeng, Hung, Cotton, & Wang, 1979), a direct comparison of subjects' performances on kana and kanji stimuli may not be appropriate. Besides, words that are written in kanji are not commonly found transcribed in kana, and vice versa. Therefore, one can not have a control for the familiarity of the stimuli.

Fortunately, there is another ethnic group whose writing system resembles that used in Japan and China. For many centuries, Koreans have been using two different types of scripts, Chinese (ideogram) and Hangul (alphabet), as in Japan. But there are numerous differences that would favor Korean as an appropriate script for studies of laterality and script effects. While the number of characters of kana transcription outnumbers that of the kanji symbols, the number of syllables (or configurations) of transcription between Chinese and Hangul, where linguistic unit is not a word but a syllable, is always identical.

More importantly, many of kanji characters are polyphonic (more than one way to pronounce the character) and have several meanings according to their pronunciations, but almost all of the Chinese letters that are used in Korea are monotonic (one pronunciation only) and have a single meaning. For example, the character [性] will be pronounced [see] when it means "sex," [ʃoo] when it means "disposition," and [saga] when it means "custom" (Paradis et al., 1985). However, the same character will only be pronounced [seong], which means "sex." Also it is very common for both Hangul and Chinese transcriptions of common words appear in everyday text, although the majority of personal writings by younger generation are written in Hangul.

Finally, the difference in direction of reading the scripts between the two ethnic groups could have a significant impact on the pattern of brain laterality. Vertical writing is still more common in Japan with columns written right to left, while the left-to-right horizontal writing is the norm in Hangul reading. This difference in orientation needs to be considered as a relevant factor (Barton, Goodglass, & Shai 1965; Bryden, 1986; Obler & Albert, 1978) when comparing performance on various script (e.g., either kana in Japan or Hangul in Korea vs. English). Considering those factors that could differentially influence the hemispheric laterality of these two ethnic groups, there are therefore some clear advantages to using the Korean subjects to investigate laterality among biscriptual readers.

Concreteness of Word Referents in Studies of Laterality

Among many factors that might help determine right hemisphere involvement in language processing, concreteness has been most extensively studied. Studies of deep dyslexics suggest that reading disability may not be equally serious for all word classes (Patterson & Marcel, 1977). It has been found that these patients have most trouble in reading grammatical and function words and abstract, low-frequency words, while they do better with common concrete words, especially nouns. They also cannot pronounce orthographically acceptable nonwords (e.g., blark). Further errors in reading concrete words are typically paralexic (substituting the right word with semantically close one, e.g., "rock" for "stone"), suggesting that a phonological lexical route (LH) has been damaged, but a relatively more direct route has been spared for those high-frequency, concrete nouns.

Visually based lexical processing capability of the right hemisphere is also implied by the studies of temporal lobectomy patients, wherein patients with right temporal lobectomy (RTL) showed poor performance on the analysis of visual features of verbal material. Jones-Gotman and Milner (1978), for example, found that on a paired-associate learning task using concrete, high-freqency words, patients with RTLs performed worse than normal controls, whereas they performed equally well on a task using abstract, low imagery words. They concluded that RTL patients could not use visual mnemonic devices as an aid to the recall of concrete words, an advantageous strategy the normal subjects were able to use to their benefit (cf. Rausch, 1981).

Analogous results have been reported in Japanese studies. Patients with left hemisphere lesions showed difficulty in reading kana, while those with right hemisphere lesions had more frequent problems with kanji (Sasanuma, 1975; Sasanuma, Itoh, Mori, & Kobayashi, 1977). This suggests at least the possibility that there is some direct lexical accessing of concrete words via the right hemisphere. As noted above, kanji and kana differ on several dimensions besides concreteness.

Several experimental studies (Day, 1977; Ellis & Sheperd, 1974; Marcel & Patterson, 1978) have also found that recognition of abstract words yielded a left hemispere superiority but there was no cerebral asymmetry with concrete words (nouns only) in a lexical decision task.

Numerous attempts have been made to replicate this pattern of interaction, but some of the studies have failed to observe the interaction of concreteness and visual field (Boles, 1983; Lambert & Beaumont, 1981, 1983; Patterson & Besner, 1984). Bradshaw and Gates (1978), for example, unilaterally presented high- or low-frequency words, half of which were abstract, half concrete. The size of the right visual field advantage was identical for all four of these classes of words, both in a naming task and in a manual reaction time task.

It is worth noting that the conclusion of right hemisphere capacity to process certain aspects of the lexicon is based on a lack of cerebral asymmetry as opposed to the usual right visual field advantage (Koff & Riederer, 1981).

Gender and Handedness

Evidence has accumulated in the literature on monolinguals suggesting that the standard pattern of cerebral lateralization (i.e., left hemisphere superiority for verbal tasks) is more characteristic of males than females (McGlone, 1977, 1978; Waber, 1979). Hannay and Malone (1976) found that while dextral males demonstrated a right visual field effect for verbal stimuli, dextral females showed no such effect. This clearly suggests that females are less lateralized in the left hemisphere than males for linguistic processing.

Similar evidence has been obtained in the bilingual literature as well (Gordon, 1980; Vaid & Lambert, 1979), but generally the potential contribution of the factor of gender differences in lateralization has not been scrutinized. Obler et al. (1982) say that one third of the bilingual studies do not report the gender composition of their subject samples and even where reported, less than one third of the studies have an equal ratio of male vs. female. Therefore, it is essential to consider separately the male and female data in laterality studies, for both monolingual and bilingual.

It has been repeatedly observed that dextral males show the most consistent lateralization patterns for verbal tasks (Bradshaw, 1980; Joanette, Lecours, Lepage, & Lamoureux, 1983; Miller, 1983). Other studies (Cohen, 1972; Harcum, 1978; Kinsbourne & Hiscock, 1977) have reported that almost 80% of all male dextrals without familial sinistrality are lateralized for their first language in the left hemisphere. This statistic is reduced to 50% for dextrals with sinistrality or ambidextrality in their immediate families (Kellar & Bever, 1980).

However, the evidence on the question of whether the factor of handedness has similar effect for monolinguals and bilinguals is very scarce. After reviewing the relevant literature, Obler et al. (1982) said that all but two studies in the bilingual laterality literature have compared left-handers versus right-handers. But even these two studies (Ohrbach, 1967; Gaziel, Obler & Albert, 1978) present disparate results: no hand difference between the two Hebrew-English bilinguals in the former study but the interaction between handedness and language in the latter study, for the same ethnic group.

While experimental studies generally use dextrals, many do not use familial dextrals or a specific questionnaire to identify familial sinistrality. Evidence from dichotic and visual half field studies indicates that sinistrals demonstrate less evidence of differences in ear effects or visual field effects. Therefore, only familial dextral males comprised the selected subjects sample for both experiments in this study, i.e., right-handed males with right-handed families.

Goals of the Study

Two experiments were designed to address the issue of the role and the degree of the right hemisphere involvement in language processing. More specifically, the goals of the present study were 1) to demonstrate the basic cerebral asymmetry pattern of left hemisphere superiority for familial dextral male monolinguals (English speaking subjects) to establish the validity and the reliability of the experimental paradigm chosen; 2) to identify the differences in cerebral laterality between a syllabic (Hangul) and an ideographic (Chinese) script as well as between two languages (Korean and English) for familial dextral male bilinguals; 3) to compare the pattern of asymmetry for English between the monolingual and bilingual groups; and 4) to delineate the effect of word concreteness and number of syllable on these patterns of asymmetry.

Specific rationale and hypotheses will be presented in the next chapter, following a more detailed and focused review of relevant literature.

CHAPTER II

REVIEW OF THE LITERATURE

Cerebral Asymmetry

The study of the brain lateralization is over a century old. Up until the mid-nineteenth century, it was firmly believed from animal studies that the two human cerebral hemispheres were not only structurally but functionally equivalent. But the classic work by Dax and Paul Broca (cited in Springer & Deutsch, 1985), which stated that damage to a certain frontal area of the left hemisphere results in disturbances of speech (aphasias) that do not occur following similar damage to the right hemisphere, introduced a new chapter in the study of the correlation between the neurological deficits and cognitive and behavioral malfunctioning. Since speech and language are so crucial to the quality of human life, it is no surprise that the majority of the cerebral laterality studies have concentrated on the aphasias and the function of the left hemisphere (Bryden, 1982).

Broca went on to try to explain the hemispheric asymmetry in language, without much success, by proposing that the convolutions of the left hemisphere develop earlier than those on the right side and that children use more developed part of the brain to aquire speech. Much later, Marie (1922) presented two other explanations for the left hemisphere dominance in language: 1) the left hemisphere becomes dominant because it matures faster; and 2) its blood supply is better than that of the right side. But these were generally rejected by investigators (cited in Lebrun, 1983).

More recently, a considerable amount of evidence has accumulated that there are definite regional structural asymmetries between the two hemispheres (Galaburda et al., 1978; Witelson, 1977). Among them, a pioneering study done by Geschwind and Levitsky (1968) found a striking asymmetry of the portion of the upper surface of the temporal lobe behind the gyrus of Heschl. In the dominant hemisphere, it is part of Wernicke's area, an injury of which generally results in sensory aphasia. They concluded that this structural difference might be related to cerebral dominance for the left hemisphere in language processing.

Goldberg and Costa (1981) suggested that even though a structural hemispheric asymmetry may not necessarily represent a dichotomy for any particular functional attribute, the left hemisphere does have more prefrontal area for sensory and motor-specific representations and these areas are characterized by a greater grey-to-white ratio of brain tissue. This could mean more rigorous and complex intra-regional communication in terms of neural organization. Gur, Packer, Hungerbuhler, Reivich, Obrist, Amarnek and Sackeim (1980) also reported a statistically significant difference between the ratios of grey to white matter in some regions of the left hemisphere versus homologous regions of the right hemisphere which may indicate more complex inter-regional connectivity. However, it is not widely accepted that any of these anatomical or structural asymmtries constitutes the neural basis of hemispheric dominance.

Although many investigators began to accept the idea that structural asymmetry reflects functional asymmetry and vice versa (Dewson, 1977; Dimond, 1977; Geschwind, 1974; Warren, 1977), more evidence of direct correlation is needed. Indeed, one author notes that "although there may be an apparent directional correlation between anatomical asymmetry and functional asymmetry, it does not prove that the anatomical asymmetry is a substriate for the functional

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asymmetry, or that functional asymmetry is a manifestation of the anatomical asymmetry. In fact, the statistical distributions of each asymmetry are sufficiently disparate to cause concern for such interpretation" (Witelson, 1977, p.340).

Right Hemisphere Capabilities

In his paper of 1865, Broca maintained that only articulate speech was lateralized to the left hemisphere. He believed that verbal comprehension and the general ability to use symbols depended equally on both sides of the brain. Jackson (1876) also believed that the right hemisphere could contribute significantly to language function, advocating that even the right hemisphere is capable of producing speech, in particular, automatic speech such as expletives and well-known phrases.

However, their insights have been relatively neglected until fairly recently, when people started to accept the view that hemispheric specialization may represent a continuum where a certain type of verbal stimuli can be processed in the right hemisphere and certain types of nonverbal stimuli can be processed in the left hemisphere (see Bradshaw & Nettleton, 1981; Whitehouse, 1981 for reviews). The following section of the literature review will by no means try to attempt to integrate all the relevant data covering the history of controversy of this idea of the continuum in lateralization. Rather the focus will be focused on the findings that have direct relevance to the rationale of the present study.

Evidence from Clinical Studies

Despite these early suggestions, the fact that severe disturbances of language in right-handers occur almost exclusively after lesions of the left hemisphere (Luria, 1970; Penfield & Roberts, 1959) led to the belief that the right hemisphere had no role in any language processing. Zangwill (1967) reviewed 2133 cases of brain damage previously reported in the literature. Of those with left hemispere damage, 59.7% of the right-handers were aphasic, while 54.9% of the left-handers were aphasic. Of those with right hemisphere damage, only 1.8% of the right-handers were aphasic, and 29.2% of the left-handers were aphasic.

Bogen and Vogel (1963) undertook a complete commissurotomy on patients with severe epilepsy. These patients were subsequently unable to name objects which were palpated by the left hand out of view or whose pictures were flashed briefly to the left visual field. This was regarded as an evidence of a prevailing left hemisphere localization for language processes. Based on these early findings, Geschwind (1965) proposed that the right hemisphere is totally incompetent in understanding verbal stimuli. He described the right hemisphere of the "split-brain" patient as "word-blind" or "word-deaf." This view implies that damage to the right hemisphere should not interfere with the use of language. But in the last two decades, clinical evidence has not supported this extreme position.

Although split-brain studies have confirmed that the left hemisphere is the prime mediator of speech and other language abilities in most people, it is also the results of these same split-brain studies that have demonstrated the linguistic competence of the right hemisphere.

One classical split-brain study conducted by Gazzaniga and Sperry (1967) showed that patients could comprehend and respond to some verbal input when the printed words--highly imageable and concrete object nouns--were flashed to the right hemisphere, and had relatively little or no trouble retrieving the corresponding object with the left hand from among several item that are hidden from view. But their performance level dropped to chance when they had to respond to verbs. This contrast in performance implies that as long as responses were signaled nonverbally, the right hemisphere was seen to have at least a modest receptive vocabulary and functional associations among the lexical items.

Further studies on split-brain patients (Levy & Trevarthen, 1977; Springer & Gazzaniga, 1975; Zaidel, 1978a) also showed that the disconnected right hemisphere was capable of understanding the meaning of the simple words but was incompetent on tasks requiring phonetic analysis and seemed to possess very little syntactic capability (Gazzaniga, 1970; Gazzaniga & Hillyard, 1971).

Springer and Deutsch (1985) remarked that "since the actions (such as smiling) required by the verbs could be controlled by either side of the brain, differences in the ability of the two hemispheres to produce the required movements were not responsible for the results. Instead, there seemed to be a genuine difference in the kind of written material each hemisphere could understand" (p.38).

The structure of the right hemisphere lexicon seems to be contrasted to that of the left in that it possesses no phonetic encoding, and no grapheme to phoneme correspondence rules (Zaidel, 1978b). This was demonstrated by its inability to match meaningful or nonsense rhyming words. In other words, the right hemisphere could not match the same meaningful rhyming words that it could read quite well in the sense of matching them with their pictorial referents or in the sense of matching the spoken name with its correct spelling. In the case of printed nonsense words, the right hemisphere could match them neither for rhyming nor with the spoken names. It would seem to follow that the right hemisphere has never acquired grapheme-to-phoneme correspondence rules and therefore reads without intermediate phonetic recording. Thus, the right hemisphere appears to be able to understand written or spoken words by direct association to meaning, but it is not capable of phonetic analysis or the recognition of meaningless consonant-vowel syllables (Levy, 1974).

Other reports have suggested a variety of specific deficits in language functions following right hemisphere lesions. Eisenson (1962) found evidence for a slight impairment on vocabulary and sentence completion tasks, especially those involving abstract concepts and words. Critchley (1962) suggested the presence of change in articulation, naming errors, and difficulties in learning new verbal material.

In another study, Weinstein (1964) maintained that denial of illness, disorientation and confabulation, and a variety of naming difficulties following right hemisphere lesions reflect right hemisphere involvement in the relationship between language and perceptual and emotional processes on which metaphorical speech is dependent.

Other studies performed on patients with unilateral right hemisphere damage showed that the language of such patients is often excessive and rambling: their humor is often inappropriate; they tend to focus on insignificant details or making tangential remarks; and the usual range of intonation is frequently lacking (Ross & Mesulam, 1979; Wapner, Hamby, & Gardner, 1981). These characteristics in speech led to the conclusion that the ability to integrate linguistic units into coherent stories had been disrupted by the RH lesions.

Evidence from Experimental Studies

The neuro-anatomical arrangement of nerve fibers from human visual system is such that when someone is fixating at some point, information falling in one lateral visual hemifield will be first projected to the hemisphere that is contralateral to that visual field. Thus, provided we know where a subject is looking at a particular moment, we can present stimuli to either hemisphere independently of the other. Based on this notion, many of laterality studies have adopted this visual half-field procedure to investigate hemispheric differences in information processing ability.

One of the most extensively studied stimulus variables that may affect the pattern of visual half field effects was word concreteness. For example, in their word recognition task, Ellis and Sheperd (1974) found a greater left-right asymmetry in manual response latency for abstract words than for concrete nouns, with the latter being recognized faster than the former at the right visual field but not at the left visual field. They concluded that this supports the concept of direct lexical access for concrete nouns, presumably via a directly generated image, while the left hemisphere processes abstract words via an indirect phonological route. Likewise, Marcel and Patterson (1978) employing a recognition technique with backward masking showed a similar effect of imageability on the pattern of lateral asymmetry as in Ellis and Shepard study. In fact, very few low-imageability words were correctly reported when in the left visual field, leading Marcel and Patterson to assert the probable role of the right hemisphere in directly accessing the lexicon by a nonphonological, imageable route.

Day (1977) found that recognition of abstract words yielded a right visual superiority but there was no cerebral asymmetry with concrete words (nouns only) in a lexical decision task. Day also found a similar pattern of laterality in other experiments involving semantic decisions as to superordinate category membership. He concluded that while concrete nouns can be processed equivalently by either hemisphere, the meaning of the visual configuration of the abstract words needed to be transfered to left hemisphere for further linguistic processing.

In a lexical priming study (Deloche, Seron, Scius & Segui, 1987), homographs and ambiguous words were biased according to the prime toward their low or high imageable meanings and unilaterally presented in the visual field. A RVF-LH advantage was obtained for the low imageable meanings of the homographs only. This suggests that for the concrete or highly imageable nouns, both hemispheres are equally efficient in accessing lexical entries, while abstract or low imageable words might be better accessed by the left hemisphere.

Right hemisphere involvement has also been demonstrated in the processing of concrete imageable nouns in the Japanese ideographic script, kanji. For example, Elman, Takahashi, and Tohsaku (1981) found no visual field asymmetry for concrete single kanji words but significant RVF-LH advantage with abstract words where subjects were asked to name the tachistoscopically presented words. At the same time, a right visual filed-left hemisphere (RVF-LH) advantage was found for kana, the phonetic and syllabic-based script (Besner, Daniels, & Slade, 1982; Elman et al., 1981; Hatta, 1977; Hink, Kaga, & Suzuki, 1980; Sasanuma, Itoh, Kobayashi, & Mori, 1980). More extensive discussion on the results of the study of biscriptual subjects will be presented later on.

The auditory system is not as precisely contralateral as the visual system, yet sounds presented to each ear simultaneously do appear to have preferred access to the opposite hemisphere (Kimura, 1961). MacFarland, MacFarland, Bain and Ashton (1978) paired words with competing speech stimuli and found an right ear advantage for abstract words in a running-memory-span task but no ear asymmetry for concrete words, suggesting that the right hemisphere ability to recognize concrete but not abstract words is not limited to the visual modality. It has been also found that linguistic features of speech, such as intonation contour and pitch processing, are often better processed by the right hemisphere (Zurif, 1974; Zurif & Mendelsohn, 1972).

Failures to observe the interaction of concreteness and asymmetry were noted in the introduction (Boles, 1983; Bradshaw & Gates, 1978; Lambert & Beaumont, 1982, 1983; Shannon, 1979). Lambert and Beaumont (1982) and Orenstein and Meighan (1976) suggested that the inconsistency might be due to subtle methodological details, such as orientation and location of laterally presented words, attentional bias, and order of report. In a review of right hemisphere language capabilities, Bradshaw (1980) concluded that "a number of clinical and neurological findings support the concept of direct lexical access being possible, via the right hemisphere for high-frequency, concrete or imageable items; the left hemisphere's phonological mechanisms would be more adapted for the analysis and interpretation of low-frequency, abstract or nonimageable material" (p.182).

Refinement of the Concept of Cerebral Asymmetry

Elaboration of right hemisphere capabilities has also helped specify other left hemisphere capabilities and further weakened the simple dichotomous explanation of cerebral asymmetry (i.e., LH for linguistic and RH for nonlinguistic processing). For example, studies furnished evidence that the left hemisphere as well as the right hemisphere could process visuospatial information, since the left hemisphere also appeared to be able to process nonlinguistic stimuli such as familiar forms and shapes (Hannay, Dee, Burns, & Masek, 1981), upside down faces (Bradshaw & Nettleton, 1981; Orenstein, Johnstone, Herron, & Swencionis, 1980), and music (Bever & Chiarello, 1974; Gordon, 1978; Johnson, 1977; Kellar & Bever, 1980;

Wagner & Hannon, 1981). Evidence from aphasia studies suggests that dextrals use both hemispheres to mediate familiar faces and their right hemisphere to mediate unfamiliar faces (Benton, 1980).

On the other hand, demonstrated right hemisphere capabilities have gradually extended from exhibiting equal potential in processing simple redundant high-frequency imageable nouns (Caplan, Holmes, & Marshall, 1974; Day, 1977; Ellis & Sheperd, 1974; Hines, 1977) to certain elementary syntactic processes such as subject object relations, tense, and plural markings (Zaidel, 1983). Thus even though the original dichotomous explanation lingers on in the media as well as among many researchers, others are beginning to adopt the view that hemispheric specialization may represent a continuum wherein certain types and aspects of verbal stimuli can best be processed in the right hemisphere, and certain types and aspects of nonverbal stimuli can best be processed in the left hemisphere (Whitehouse, 1981).

Orthography and Laterality

The major issue in this study has to do with an assumption that the symbol-sound correspondence between orthography and spoken language might play a significant role in determining the level of participation in linguistic processing by the two sides of the brain. An ideographic script such as Chinese does not have such a correspondence at a "sublexical" level, while phonetic scripts display letter-sound correspondences.

Evidence from Clinical Studies

Evidence supporting this assumption comes from two different sets of studies: intra-hemispheric and inter-hemispheric studies. First, at intra-hemispheric level, since readers of a language with a phonetic script may rely more on auditory than visual processing, one would expect them to experience more severe alexia or agraphia than readers of an ideographic script, following damage of the left temporal cortex. Conversely, greater impairment in reading should accompany left occipital damage among readers of an ideographic script relative to readers of a phonetic script. Therefore, it was hypothesized that within the left hemisphere, damage to a particular cortical area (temporal vs. parieto-occipital) will produce a differential pattern of reading and writing deficits across the two languages (Vaid, 1983).

In support of this hypothesis, Luria (1960) reported greater impairment in writing French (which has a less direct sound-symbol correspondence) than Russian following a left inferior parietal lesion. Lyman, Kwan, and Chao

(1938) reported greater impairment for written Chinese than English after a left parieto-occipital injury, also in support of this hypothesis. Similarly, several case studies of Japanese aphasics have reported selective impairment in reading or writing kanji (ideographic script), following left parieto-occipital damage, and kana (phonetic script), following left temporal damage (Sasanuma, 1975).

After reviewing 69 case studies of Japanese alexics, Paradis et al. (1985) also came to the conclusion, which supports Vaid's (1983) hypothesis, that the correlation between locus of lesion and type of dissociation seems to point to a greater involvement of the left temporal area for kana processing, and of the left parieto-occipital area for kanji processing, for both reading and writing.

Several interpretations of these dissociations between kana and kanji in reading and in writing have been offered. The most widely held points to the necessity of a phonological processor for the kana to mediate the grapheme-sound-meaning correspondence (Sasanuma, 1975, 1980; Sasanuma & Fujimura, 1971; Tatsumi, Itoh, Konno, Sasanuma, & Fujisaku, 1982).

For inter-hemispheric comparisons, it was hypothesized that phonetic script should be more efficiently handled by the left hemisphere, due to its strong linguistic capabilities including phonological processing, while the right hemisphere is more adept to process holistic, visuospatial relations as found in ideographic script. In support of this hypothesis, Sugishita, Iwata, Toyokura, Yoshioka, and Yamada (1978) reported that reading of kanji presented in the left visual field was preserved in a Japanese commissurotomized patient, while reading of kana was impaired.

Watanabe, Hojo, Sato, Sakurada, Tanaka, and Shimoyama (1979) reported two cases of patients who had had their splenium of the corpus callosum severed surgically, thus partially isolating the two hemispheres. The tachistoscopic performance of kana and kanji recognition showed that the ability to recognize kanji characters was significantly impaired when they were presented to the right hemisphere, which could be interpreted as evidence for right hemisphere involvement in processing kanji characters.

Right hemisphere involvement has also been reported in the processing of Chinese characters, from which kanji are derived. In a case study of a tridialectal aphasic, comprehension of isolated Chinese characters was preserved in contrast to a marked impairment in nearly all other language modalities (Naeser & Chan, 1980). Two case reports of crossed aphasia (language disturbance following cerebral lesion ipsilateral to the dominant hand) in Chinese-English bilinguals have also implicated the right hemisphere in the processing of Chinese characters (April & Han, 1980; April & Tse, 1977) especially if they are pictographic (i.e., bearing a resemblance to the object or event named) compared to nonpictographic characters (Nguy, Allard & Bryden, 1980).

Similarly, a right-handed commissurotomy patient was reported to be agraphic in kana but not in kanji when writing with his left hand (Sugishita, Toyokura, Yoshioko, & Yamada, 1980). Yamadori (1980) interpreted the superiority of writing performance of kanji as evidence of the right hemisphere's ability to execute, as a unit, motor engrams of both kanji and kana. A grapheme as a functionally and morphemically complete unit can be produced by the right hemisphere irrespective of the type of script. However, kana words are comprised of several characters. This serial output of kana characters presupposes a phonemic control that is not available in the right hemisphere. Kana decoding without phonetic control results in clumsy grapheme production. If an output is kanji, the right hemisphere can still mediate meaning because kanji is a lexical morpheme and has meaning. Thus, it is the different processing mode of the two hemispheres that produces a dissociation between kana and kanji.

Evidence from Experimental Studies

A number of Japanese studies found that kana script was more easily and accurately recognized in the right visual field while kanji was recognized faster in the left visual field (Paradis et al., 1985). Hatta (1977) found that when the Japanese subjects were asked to identify single kanji characters that were unilaterally presented, their performance was superior when the characters were shown to their left visual field than to right visual field. Sasanuma et al. (1977) also found a similar laterality pattern when they presented nonsensical two-character kana and kanji words: a RVF-LH advantage for kana characters and nonsignificant trend towards a LVF-RH advantage for kanji characters. In a kanji-kana Stroop test, Hatta (1981) reported a greater kanji interference effect in LVF, while no visual field difference for kana Stroop stimuli, suggesting a specialization of the RH for kanji processing.

However, as many other studies (e.g., Feustel & Tsao, 1978; Kershner and Jeng, 1972) have reported a RVF-LH advantage for the recognition of tachistoscopically presented Chinese characters by the Chinese-English bilinguals. Hardyck, Tzeng and Wang (1978) also found a right visual field superiority for the recognition of both

Chinese and English words when they were presented repeatedly. Zhang and Yang (1986), using single- and double-character Chinese words, showed RVF-LH superiority for both Chinese and Japanese subjects, who were studying in China at the time of the test.

There are several possible causes for these inconsistent findings of Japanese and Chinese studies. One possible answer to the conflict in the patterns of asymmetry observed between Japanese and Chinese studies is that the use of two quite different scripts by the Japanese might have heightened the contrast in the processing of kanji vs. kana (Hasuike, Tzeng, & Hung, 1986).

A second possibility concerns the number of characters displayed. Tzeng et al. (1979) noted that studies that found a LVF-RH superiority for ideographic script (both Chinese and kanji) presented either a single character at a time (Hatta, 1977) or two nonsense characters (Sasanuma et al., 1977). In contrast, studies that presented two-character words obtained a RVF-LH effect (Hatta, 1978; Tzeng et al., 1979).

Two interpretations of RVF-LH advantage for double-character have been offered. Hatta (1978) argues that subjects need to use phonological (LH) strategy for the double-character kanji word naming task since only one pronunciation (monotonic) is assigned to those words (verbal mediation on visuospatial task). But since there is more than one way to pronounce most single-character kanji (polyphonic; up to 23 readings for a single kanji) it may be unnecessary to search through phonological route to name any particular character (no verbal mediation). Tzeng et al. (1979), based on the evidence that reading ideographic symbols also requires speech recoding (Tzeng, Hung & Wang, 1977), suggest that left visual field advantage for reading single character Chinese words is due to a holistic mode of processing by the right hemisphere while two-character Chinese words require a more analytic type or sequential type of processing more typically a left hemisphere function. However, Huang and Jones (1980) argue that it is neither the stimulus per se, nor the processing mode but the nature of task that determines which hemisphere processes what.

Summary and Hypotheses

Studies of functional cerebral asymmetry have demonstrated that a wide range of functions are lateralized toward one or the other cerebral hemisphere. The question is if lateralization follows any coherent pattern. Certainly, the assignment of functions to one or the other hemisphere, although seldom absolute, does not appear to be merely random. On the other hand, it is difficult to discover any single principle that might underlie it. We can reject the idea that the basic distinction is that the left hemisphere is primarily verbal and the right hemisphere nonverbal. This does not account for such findings as the left hemisphere superiority in motor-sequencing or in the perception of rhythm, nor does it explain the evidence that the disconnected right hemisphere is capable of at least some aspects of verbal comprehension (Corballis, 1983).

An attempt was made to examine the effects of word concreteness and orthography on the pattern of lateralization among Korean bilinguals. The rationale behind this was threefold. First, as was alluded to before, concreteness has been one of the most robust factors demonstrating a right hemisphere linguistic capability; but so far it has been studied almost exclusively with monolingual subjects. The evidence of concreteness by VHF effects in studies of monolinguals will be strenghtened if a similar pattern of results can be consistently obtained from studies of bilinguals.

Secondly, this group of subjects--Korean bilinguals--permits us to compare, indirectly, the pattern of cerebral lateralization in language processing of two ethnic groups (Japan and Korea). Thirdly, Koreans' use of both Hangul and Chinese scripts lets us control several potentially crucial variables, in particular the number of syllables in the transcriptions and the familiarity of the words. As noted above, kanji words are seldom seen written in kana and vice versa in Japan, which makes controlling the familiarity of linguistic materials almost impossible. To the best of our knowledge, there have been no studies that have examined the relationship between cerebral laterality and Hangul/Chinese orthographies so far.

Specific predictions that were tested for the Experiment 1 are (1)if the left hemisphere is largely responsible for language comprehension of visually presented words, then word recogniton should be faster regardless of the characteristic of the words when they are presented to the right visual field; (2) if the right hemisphere has a lexicon for concrete, high frequency words, then there should be no VHF effect for word recogniton speed at least for the concrete words.

Several other hypotheses were tested in Experiment 2: (1) since both Hangul and English belong to the category of phonetic script, the laterality pattern for these languages should not be different, with both producing a left hemisphere superiority in the speed of word recognition, despite the vast graphemic and phonological differences between Korean and English; (2) the Chinese words will be recognized faster when presented to the left visual field because of the right hemisphere's finer capability to process visuospatial linguistic information; (3) In Chinese condition, single-character words and double-character words will show a different pattern of laterality. More specifically, due to the right hemisphere's superiority in form perception and also to the lack of the necessity to go through phonological route, single words will be recognized faster when they are presented to the left visual field (RH), while double character words will be recognized faster on the right visual field (LH) if the left hemisphere's specialization for words extends to any case where a sequence of discrete symbols need to be analyzed and combined.

CHAPTER III

EXPERIMENT 1

In the first experiment, English monolinguals were asked to decide whether a series of unilaterally presented words were concrete or abstract. This particular word recognition task has been found to produce the traditional laterality effect, i.e., RVF-LH superiority. One advantage of this task is that it requires lexical access and semantic analysis of stimulus but not necessarily phonological analysis, in contrast to a naming task. By adopting this task, one can also avoid the problem of defining "nonwords" that complicates the lexical decision task.

The experiment was designed to 1) determine if, with the words and task selected, a robust RVF-LH superiority could be obtained for English monolinguals; 2) provide a basis of comparison for the performance in English by non-native bilinguals in Experiment 2; 3) assess the extent of left hemisphere asymmetry for concrete vs. abstract words when the task makes this semantic aspect of stimuli more salient; and 4) determine the effect of item repetition on concreteness and visual half field effects.

Since the control of lexical, semantic, and orthographical variables in Experiment 2 puts substantial constraints on the word set, it was necessary (as is common in other visual half studies) to _repeat_ particular words to obtain enough data per subject. By treating repetition as an experimental factor, the stability of lateral asymmetry effects can be assessed. If visual half field asymmetry reflects "structural" specialization, then the asymmetry should be obtained even after several repetitions. A second, more pratical purpose of the repetitions was to determine minimum amount of data per subject needed to obtain a robust visual half field (VHF) effect.

Method

Subjects

Twenty-four male University of Florida students from the subject pool of the Department of Psychology participated in the experiment in partial fulfillment of a general psychology course requirement. Subject selection was guided by several criteria. First, English was the native language and students who lived in foreign countries during their childhood or in recent years were excluded from the experiment. Second, all subjects were strongly right-handed according to the short version of Edindurgh

Inventory (Oldfield, 1971), and none of them had any left-handers in their immediate family. Last, no subject had any history of neurological or visual problems and eyesight was normal or corrected-to-normal.

Design and Stimuli

The experiment used a 2 X 2 X 4 factorial design with repeated measures. Visual half field (left visual field vs. right visual field), word concreteness (concrete vs. abstract), and trial block (four blocks) were the three within-group factors in this experiment. Both reaction time (msec) and accuracy in the concreteness decision task were recorded for all responses in the experimental trials.

Twenty 3- to 5-letter common nouns were chosen from word norms of concreteness, imageability, familiarity (Toglia & Battig, 1978) and frequency (Thorndike & Lorge, 1944). Among them, 10 words had been rated as highly concrete and the other 10 as abstract. According to the Thorndike and Lorge (1944) frequency norms, 9 concrete words were drawn from the category of AA, 1 from the others, while 8 abstract words belonged to AA category, 1 to A, and 1 to others. The words had also been selected to be used in Experiment 2 and therefore they were subject to further constraints: The Hangul transcriptions of the Korean transcriptions of the words were not homophonic (as are some other Hangul words), and the number of one- and two-syllable words in Korean was balanced (see Experiment 2 method). Imageability and concreteness ratings, while highly correlated, can be separated, but no attempt was made to do so here. A summary of mean ratings and standard deviations for concreteness, imageability, and familiarity is presented in Table 2.

Table 2

Mean Ratings and Standard Deviations (in parenthesis) for Word Concreteness, Imageability, and Familiarity for Concrete vs. Abstract Words

Category	Concreteness	Imageability	Familiarity
Concrete	5.66	5.75	6.43
	(.26)	(.31)	(.28)
Abstract	3.31	3.85	6.13
	(.35)	(.46)	(.30)

For each word, a stimulus card was prepared using an IBM-compatible microcomputer. The size and position of the stimuli were determined by using Microsoft Word processing software. Each word was printed horizontally on a 6" x 9" blank card in Helvetica 24-point by a Hewlett Packard LaserJet laser printer, once to the right and once to the left side of the center of the viewed area of a card. Hence, a total of 40 target cards were made. Twenty additional practice cards were constructed in the same manner. The stimulus subtended a horizontal visual angle of approximately 1.6 to 2.0 degrees (depending on the length of the word) and the centers of the right visual field and left visual field words were offset by 2.4 degrees from the central fixation point.

Apparatus

The stimuli were presented to a lighted screen located 36" from the subject, using a Iconix 4-channel tachistoscope and exposure box. Each word appeared for a duration of 120 msec, which had been found to provide high accuracy but was brief enough to prohibit eye movements to the stimulus. Two telegraph keys were arranged in front of the subjects. For half the subjects, the left key was for "concrete word" and the right key for "abstract word." For the other half, this was reversed so that the hand of response was counterbalanced.

Subjects were also able to initiate the whole cycle of a single trial by depressing a foot pedal that was interfaced with the T-scope. Using a PDP-11 minicomputer, a BASIC program was written to generate the whole sequence of the stimulus words and their corresponding number for the cards so that the experimenter could present them to the subject. A video terminal was adjacent to where the experimenter was sitting, allowing the speed and accuracy of responses to be entered on-line for later analyses.

Procedure

Subjects were tested individually in a single session lasting approximately 55 min each. Each session had four blocks of 40 target trials for a total of 160 trials. Twenty practice trials were given to accustom the subjects to the concreteness decision and to the procedural details. Before the experiment began, subjects were informed of several important things. First, they were briefed about how the equipment was set up and how it functioned. Secondly, the importance of eye fixation and concentration throughout the whole session was emphasized. Finally, the nature of the experimental task was explained to the subjects by giving some examples of concrete words and abstract words. Since the concreteness ratings of abstract and concrete words were significantly different, $\underline{t}(1,10)=47.5$, $\underline{p}<.01$, confusion on the task was neither anticipated nor observed before and during session.

At the start, subjects were informed that they would be shown a fixation point (*) at the center of the screen and that a word would follow quickly either in the right or in the left visual field and that they would have to decide, as quickly as possible, whether the word was a concrete word or an abstract word by depressing the appropriate key in front of them. The inter-trial interval was approximately eight seconds and the between-block interval was about a minute. On each trial, the following events happened: (1) The experimenter said "ready" to alert the subject to the start of the trial. (2) By depressing the foot pedal which was located beneath the desk, a fixation point was given .5 sec later for 200 msec. (3) The fixation field was replaced by the test word in random fashion either on the right or on the left visual field for 120 msec. The random order was constrained in that a maximum of three consecutive trials of a given type (e.g., concrete-left) would occur. (4) The subject decided whether the test word was a concrete word or an abstract word. The decision latency and the occurrence of errors were recorded by the experimenter.

Results

Overall Analyses

Latency was measured from the onset of a test word until the decision was made by depressing either one of the two telegraph keys. Responses with latency of over 2 sec were treated as errors. For each subject, mean response latency for correct trials was derived separately for each of the 16 Concreteness by VHF by Block conditions and served as a single score in the analyses to follow. For each condition, up to 10 correct responses could be recorded. Error rates were too low (mean error rate of 3.5% and maximum of 5%) to be analyzed statistically. There was no evidence of any speed-accuracy tradeoffs. Hence, no further analysis was considered necessary. Table 3 presents the mean latency and standard error for each condition across subjects.

Table 3

Mean Latency (msec) and Standard Error (msec) of Decisions as a Function of Word Concreteness, Visual Half Field and Trial Block

	Test Word			
Trial	Concrete		Abstract	
Block	RVF	LVF	RVF	LVF
1	606 (29) 53[a]	659 (31) -	723 (38) 85	808 (43) -
2	523 (19) 36	559 (27) -	605 (24) 36	641 (31) -
3	495 (20) 34	529 (36) -	519 (21) 64	583 (21) -
4	496 (35) -	482 (24) 14	495 (18) 34	529 (18) -

[a] the size of VHF advantage in milliseconds

In a 2 (Concreteness) x 2 (Visual Half Field) x 4 (Block) repeated-measures analysis of variance (ANOVA), treating subjects as the random effect, the main effect of Concreteness was significant, $F(1,23) = 26.67$, $p<.01$, with concrete words responded to more quickly than abstract words. There was also a significant main effect of VHF, $F(1,23) = 33.53$, $p<.01$, with words presented to the right visual field responded faster than those presented to the left visual field. The main effect of Block was also significant, $F(3,69) = 42.56$, $p<.01$, with responses becoming faster as the words were repeatedly presented.

The only significant interaction was between Concreteness and Block, $F(3,69) = 7.68$, $p<.01$. Table 4 gives combined mean scores across the VHF for abstract and concrete condition for four blocks. As can be seen, the interaction resulted from the decreasing concreteness effect across block: the biggest effect was in Block 1 and it decreased systematically.

Table 4

Mean Latency (msec) for Concrete and Abstract Words across the Visual Half Field for Four Trial Blocks

Trial Block	Concreteness		Simple effect	
	Concrete	Abstract	F(3,69)	p
1	633	766	33.9	<.01
2	541	623	12.9	<.01
3	512	551	2.9	<.05
4	489	512	1.0	>.10

The results of simple effects tests showed that Concreteness remained significant. More importantly, the Concreteness x VHF interaction did not reach significance, $F(1,23) = 2.24$, $p>.10$, although the trend was in the same direction that other studies have suggested: the RVF advantage (LVF-RVF) for the abstract words was 83 msec while it was only 55 msec for the concrete words. Moreover, the RVF advantage was larger for abstract words in each of the four trial blocks. No other interaction was found to be significant, VHF x Block $F(3,69) = 1.62$, $p>.19$, and Concreteness x VHF x Block $F(3,69) <1.00$.

A separate ANOVA was conducted for the first two blocks of trials to see how stable the pattern of the laterality was. The reason for doing an additional analysis had to do with the design of the following second experiment in which subjects were supposed to have trials on three different scripts. Since the total number of trials in the second experiment could be unacceptably large due to the nature of within-subject design (each subject gets all three types of scripts), it was necessary to decide on a minimum number of trials that would show reliable laterality effects.

Results of this 2 x 2 x 2 ANOVA were equivalent to the 4-block analysis all main and interaction effects. Most importantly the VHF effect remained significant.

Analysis by Items

Since the size of the stimulus set was small, response latencies were also analyzed treating the items as the random effect to test the reliability of the linguistic materials chosen. To do that, response latencies for each of the twenty words in each VHF by Block condition were averaged across subjects and served as a single observation. The results of the items ANOVA were in complete agreement with the subjects' analyses.

Discussion

The results of Experiment 1 were as follows: (1) Overall, words presented to the RVF were responded to faster than those presented to the LVF; this was found in for all four trial blocks. (2) The size of RVF-LH advantage tended to be greater for the abstract words than for the concrete words, but the effect did not reach significance. (3) Concrete words were recognized faster than abstract words. (4) Not surprisingly, there was a significant repetition effect. (5) The size of concreteness effect decreased as the number of repetitions increased.

The clinical and experimental literature reviewed above suggested that the right hemisphere has a lexicon consisting primarily of concrete words, represented semantically and visually, but not phonologically (Levy & Trevarthen, 1977; Zaidel, 1978). It was predicted that if there should be evidence of right hemisphere involvement in this word recognition task, then the usual RVF-LH advantage would be reduced or eliminated for concrete words. An extreme view would be that the RH is better at processing concrete words than the LH: in that case, a LVF-RH superiority could be observed. The results showed some reduction in the size of the RVF-LH advantage but the trend did not reach significance.

In a Go/No-go reaction time task to concrete and abstract words, Moscovitch (1981) also found a RVF-LH advantage across all classes of words, although concrete words produced smaller VHF effect than abstract words.

These findings suggest that regardless of the right hemisphere's apparent capacity to process verbal information semantically, right-handed monolinguals rely on the left hemisphere's superior abilities in this domain.

CHAPTER IV

EXPERIMENT 2

The first experiment established the appropriateness of task and materials for eliciting the basic RVF-LH effect. One of the other major linguistic variables besides word concretenesss that has shown strong evidence of right hemisphere capability in language processing concerns orthography. Experiment 2 was designed to test the assumption that a phonetic script will be more easily and quickly recognized by the left hemisphere due to its capability of phonological processing, while an ideographic script will be recognized faster by the right hemisphere because of its ability in handling visuospatial information. Word concreteness and number of syllables were also manipulated. The rationale behind this and other specific hypotheses has been presented in Chapter II.

Method

Subjects

Twenty-four Korean students at the University of Florida participated in the experiment. They were recruited by personal contact of the experimenter and were paid five dollars for serving as subjects. All were right-handed males. Mean length of residency in the United States was approximately 3 years 2 months with the range from 1 year 6 months to 5 years 6 months. All were strongly dextral, according to the short version of the Edinburgh handedness test (Oldfield, 1971). An additional checklist requested the handedness of members in the immediate family. Subjects whose parents or siblings were left-handed or ambidextrous were excluded from the study. No subjects had any previous history of neurological damage and their eyesight was normal or corrected-to-normal.

All subjects had at least seven years of formal English education and of Chinese script (written language only) and they were initially exposed to both languages before puberty. However, it is noteworthy that they have had more intensive curricula in English than in Chinese during their schooling, and their experience of Chinese language is almost exclusively limited to reading comprehension. But in view of the familiarity of the word sample, all the language materials that were employed in this experiment were well within their lexical repertoire.

Design and Stimuli

The experiment used a 2 x 2 x 2 x 3 factorial design with repeated measures. Concreteness (concrete vs. abstract), Visual Half Field (left visual field vs. right visual field), Syllable (single vs. double syllable), and Language (Hangul vs. Chinese vs. English) were four within-group factors in the experiment. Dependent measures and experimental task were the same as in the previous experiment.

Twenty-eight English nouns, 20 from the original list of Experiment I and 8 others that were selected based on the same criteria, and their translations in Hangul and in Chinese were used in this study. Note here that not only do Hangul words and Chinese words have exactly the same meaning but also they are pronounced the same: in other words, they are transcriptions of each other. Preparation for the selection of the stimuli was rather complicated due to several factors. Since both experiments were designed to utilize a similar subset of linguistic materials to compare the results in more direct manner, many word characteristics had to be considered at the same time for a certain word. Among those characteristics of the words, some served as independent variables, such as concreteness, and number of syllables, and some were controlled for, such as frequency, length and familiarity. In addition, the complexity of the character (here defined as the number of strokes per character) of Chinese ideogram was controlled for in the process of stimulus selection.

Unfortunately, norms for these characteristics were not available for Hangul and Chinese in a Korean population. However, it seems likely since most of the words used were translations of English words used in Experiment 1, there should be a high correlation between the ratings of linguistic variables across the three scripts.

For Hangul and Chinese, then, half of the 28 words were concrete according to English norms, and the rest were abstract. Also within each of these subsets, half of them were monosyllabic and the rest of them were double-syllable words. Table 5 presents the summary of the characteristics of the stimuli that were adopted for this study.

Table 5

Mean English Ratings and standard deviations (in parenthesis) for stimulus characteristics of Chinese and Hangul words

	Word set			
	Concrete		Abstract	
	Single	Double	Single	Double
Concreteness	5.71	5.70	3.38	3.19
	(.28)	(.40)	(.40)	(.23)
Imageability	5.72	5.83	3.91	3.82
	(.30)	(.30)	(.44)	(.56)
Familiarity	6.41	6.35	6.03	6.25
	(.27)	(.33)	(.36)	(.18)
No. of Strokes[a]	8.86	14.40	9.00	14.60
	(1.40)	(2.77)	(1.20)	(2.38)

[a] Chinese characters only

Apparatus and Procedure

Equipment settings for the study were the same as for the first experiment. The experimental procedure was very similar for both experiments except the number of trials: since each word was seen twice, once to the right and once to the left visual field, each subject had 56 trials for each language, for a total of 168 trials. In addition, they were also given 12 practice trials in each language to accustom them to seeing the particular language that they were going to be tested on in each block. Number of syllables, visual field and concreteness were varied randomly over trials within a block, but language was blocked. Order of the presentation of there scripts was also counterbalanced across subjects. Written instructions were given in English, then a few crucial aspects of the procedure were reiterated in Korean. All the events that occurred on a single trial in this experiment were identical with those in the first study.

Results

Overall Analyses

Latency was measured from the onset of a test word until the decision was made by depressing either one of the two telegraph keys. For each subject, mean response latencies for correct trials were derived separately from the 24 conditions and served as a single score in the analyses to follow. Responses with latency of over 2 sec were treated as errors. Error rates were very low (under 5%) and no further analysis was done. Table 6 presents the mean latency and standard error for each condition across subjects.

Table 6

Mean Latency (msec) and Standard Error (in parenthesis) of Decisions as a Function of Concreteness, Visual Half Field, Syllable, and Language of Test Words

	Word Set							
	Concrete				Abstact			
	Single		Double		Single		Double	
Script Type	RVF	LVF	RVF	LVF	RVF	LVF	RVF	LVF
Chinese	714	677	743	707	748	689	846	763
	(17)	(23)	(26)	(19)	(23)	(15)	(29)	(22)
	-	37[a]	-	36	-	59	-	83
Hangul	580	600	569	602	656	707	629	747
	(20)	(21)	(18)	(21)	(21)	(22)	(17)	(31)
	20	-	33	-	51	-	118	-
English	674	688	668	687	728	789	751	789
	(14)	(16)	(13)	(15)	(14)	(21)	(17)	(18)
	12	-	19	-	61	-	38	-

[a] the size of VHF advantage in milliseconds

A 2 (Concreteness) x 2 (Visual Half Field) x 2 (Syllable) x 3 (Language) repeated measures anaysis of variance was conducted, treating subjects as the random effect. The main effect of Concreteness was significant, $F(1,23) = 115.6$, $p<.01$, with concrete words responded to much faster than abstract words. The analysis of variance also showed both Syllable, $F(1,23) = 8.3$, $p<.01$, and Language, $F(2,46) = 17.63$, $p<.01$, had significant effects on decision latency; single syllable words were responded to faster than double syllable words, and also the difference in latency among the languages was significant, with Korean the fastest and Chinese the slowest. However, the effect of VHF was not significant, $\underline{F}(1,23) = 2.91$, $\underline{p} > .10$. The absence of an overall VHF effect was due to the fact that the direction of the visual half field effect for Chinese is opposite to that of both Hangul and English.

In contrast to Experiment 1, where the same trend was nonsignificant, the Concreteness x VHF interaction was now significant, $\underline{F}(1,23) = 6.63$, $\underline{p} < .01$, with the size of VHF effect greater for abstract than for concrete words. The only other higher-order interaction that came out to be significant was Concreteness x VHF x Language, $\underline{F}(2,46) = 8.46$, $\underline{p} < .01$. Again this tells us that the degree of interaction between word concreteness and visual half field depends upon the language.

The interaction between Concreteness and Syllable was significant, $\underline{F}(1,23) = 6.51$, $\underline{p} < .01$, with the difference in latency between the concrete and abstract words greater with double-syllable than single-syllable words. Concreteness x Language yielded a significant interaction also, $\underline{F}(2,46) = 5.43$, $\underline{p} < .01$. Both Syllable x Language, $\underline{F}(2,46) = 9.54$, $\underline{p} < .01$, and VHF x Language, $\underline{F}(2,46) = 23.93$, $\underline{p} < .01$, also turned out to be significant.

All these significant interactions involving the language variable imply that the degree of variation in the other three independent variables is significantly different from language to language. All other interactions were not significant. The specific nature of these interactions will be examined below.

Analysis of Log-transformed Latencies

Since the number of observations per cell was small, it was possible that any wild scores in a particular condition could bias the mean score for that condition and subsequently skew the overall distributions of scores. Therefore a second analysis was performed by taking the logarithm of the original latency for each response. Means for those scores in each cell were then retransformed by taking anti-logs. These scores were treated as individual data point in new ANOVA.

The effect of this transformation is to reduce the influence of very long latencies on mean latency, thus normalizing the typical positive skewing of reponse latency distribution. The same type of ANOVA as in overall analyses was conducted. There were no discrepancies in the pattern of effects between the two ANOVAs.

Analyses by Language

Separate analyses were performed on each language script, in view of the interaction of language with the other critical variables.

Chinese. A 2 (Concreteness) x 2 (Syllable) x 2 (VHF) ANOVA for Chinese showed that there was a significant effect of Concreteness, $F(1,23) = 37.59$, $p<.01$, with concrete words being responded to faster than abstract words. A significant main effect of Syllable, $F(1,23) = 24.39$, $p<.01$, showed that single-syllable words were responded to more quickly than were double-syllable words. A VHF also yielded a significant main effect, $F(1,23) = 11.57$, $p<.01$, with words presented to the left visual field were responded significantly faster than those shown to the right visual field (LVF-RH advantage). This pattern of results is quite the contrary of that of the studies of phonetic script.

The interaction between Concreteness and Syllable was significant, $F(1,23) = 11.59$, $p<.01$, showing that the size of concreteness effect is greater for the double-syllable condition than for the single-syllable condition. The interaction of Concreteness and VHF, $F(1,23) = 3.99$, $p<.05$, was marginally significant, with a smaller VHF effect for concrete words, in accord with previous monolingual studies. No other interactions were significant.

As in Experiment 1, an item analysis was done with items as the random effect, and concreteness and number of syllables as nested variables. All the other results were very similar except the concreteness effect, $\underline{F}(1,24) = 4.5$, $\underline{p}<.05$, which was reduced here compared to subject analyses.

Hangul. Latencies in the Hangul blocks were also analyzed by a three-way ANOVA. A significant Concreteness effect, $\underline{F}(1,23) = 75.04$, $\underline{p}<.01$, was present, with concrete words being recognized faster than abstract words. There was also a VHF effect, $\underline{F}(1,23) = 30$, $\underline{p}<.01$, with words presented to the right visual field recognized faster than those presented to the left visual field. Unlike Chinese, the syllable effect did not approach significance, $\underline{F}(1,23) <1.00$.

The interaction between Concreteness and Syllable was not significant, $\underline{F}(1,23) <1.00$, but that of Concreteness and VHF was significant, $\underline{F}(1,23) = 12.47$, $\underline{p}<.01$, with a greater RVF-LH advantage in latency for abstract than for concrete words. The interaction between Syllable x VHF was also significant, $\underline{F}(1,23) = 6.49$, $\underline{p}<.01$. Other interactions turned out to be nonsignificant.

The results of the item analysis did not show any significant changes in the pattern of results.

English. The results of English trials looked very similar to those for Hangul. A significant Concreteness effect, $F(1,23) = 41.5$, $p<.01$, and VHF effect, $F(1,23) = 16.16$, $p<.05$, were present. Since the number of syllables for English translations did not correpond to those in Hangul, the syllable comparison for English was meaningless; lack of significance on Syllable effect, $F(1,23) <1.00$ was therefore not surprising. The only interaction that reached significance level was Concreteness x VHF, $F(1,23) = 7.78$, $p<.01$. Note that the same interaction failed to reach significance in Experiment 1 with monolingual subjects.

The results of the item analysis were very similar with those of the overall analyses except for a significantly reduced effect of Concreteness x VHF, $F(1,24) = 3.2$, $p<.10$.

Analyses of Position Effects

Since language was manipulated within subjects, and words with equivalent meanings were used in the three blocks, possible practice effects were examined by performing separate analyses for each script, treating position of the scripts as a factor. For all three scripts, Position turned out to be nonsignificant, in contrast to the substantial within-language repetition effect in Experiment 1. Also, there was no interaction

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between Position and any of the three independent variables (concreteness, syllable, VHF) in all three scripts.

Discussion

The main question of the second experiment was to see if words of different orthographies but of the same semantic meaning would bring about different laterality patterns in word recognition. The results of the analyses revealed the following: (1) There was a significant LVF-RH advantage for the Chinese and a RVF-LH superiority for both Hangul and English. (2) Interaction of Concreteness and VHF was only marginally significant for Chinese but strongly so for Hangul and English. In each case, the VHF asymmetry was smaller for concrete than for abstract words. (3) The latencies for the concrete words were shorter than for the abstract words for all three scripts. (4) For Chinese, single-syllable words were recognized significantly faster than double-syllable words, but there was no syllable effect for Hangul words. (5) The VHF asymmetries were found for both single- and doble-syllable Korean scripts. (6) Even though subjects had received all three scripts, there was no evidence of repetition effect despite the fact that the words contain the same semantic contents.

The results show very strong dissociations in performance between right and left hemisphere in terms of their degree of participation. For an ideographic script, the Chinese, there was clear evidence of the right hemsiphere's superiority of processing the visuospatial configurational characteristics of the words but for phonetic scripts, Hangul and English, there was a consistent left hemisphere advantage. This pattern of laterality supports some of the Japanese studies (Hatta, 1976, 1978; Sughisita et al., 1978) and rejects some other studies (Hardyck et al., 1978; Kershner & Jeng, 1972; Zhang & Yang, 1986).

These contrasting results, together with the results of the present study, suggest a comparable lateral asymmetry pattern for Japanese and Korean readers but a dissimilar pattern between the Chinese and the Korean. It is also possible that Chinese subjects, who typically have shown a RVF-LH superiority for Chinese words, may process their words in a more analytical or componential way, having started to learn these graphic words from their early childhood. They may not treat them as ideograms as foreigners or beginners would do.

In support of this conjecture, Zhang and Yang (1986) argued that for those who have grown up with ideographic characters, their appearance is closely tied to their pronunciation and meanings. This implies that Chinese subjects might be able to do phonological analysis of those characters, which could result in RVF-LH superiority for ideographic script. But there are many unanswered questions regarding this position such as how much impact the degree of hieroglyphicity of the words would have on the phonological processing of Chinese script. In other words, are highly pictographic characters have more or lesser chance of being phonologically processed (by LH) than those that are not within the Chinese language?

Regarding the resemblance of the results of the present study and other Japanese studies (e.g., Hatta, 1978), it is speculated that using two contrasting scripts might have caused this asymmetry in linguistic processing for both the Japanese and the Korean. However, any direct comparison between these two ethnic groups in their lateralization of languages should be treated cautiously due to many cultural, linguistic and educational differences between them.

Consistent with the results of the Experiment 1 was the finding of a robust advantage of RVF-LH for phonetic scripts, Hangul and English. The similar pattern of laterality for this type of script for monolingual and bilingual groups lend further support to the assertion of the previous research, which has indicated the left hemisphere's superiority in phonological processing ability.

The arguments concerning controversial results on laterality pattern of single- versus double-syllable Chinese words (Hatta, 1977, 1978; Sasanuma et al., 1977; Tzeng et al., 1979) were based on the assumption of whether the stimulus would be treated as verbal or pictorial. The gist of their argument was that double-syllable words or nonsense syllables would require sequential or analytic processing, which would result in RVF-LH superiority, while single-syllable words might be processed holistically, which is considered as a RH function.

However, the Experiment 2 failed to find the predicted interaction between Syllable and VHF, which suggests that within the script itself, there is neither differential selection of processing strategy (holistic vs. sequential or analytic) for different type of word nor is there any filtering mechanism of whether a particular word should go through a phonological processing route or not. In other words, all ideographic words appeared to be treated similiarly.

CHAPTER V

GENERAL DISCUSSION

The primary goals of the present research were (1) to determine how different orthographies and languages for word of equivalent meaning would influence hemispheric asymmetry as seen in a speeded word recognition task; and (2) since evidence has been accumulated suggesting that the right hemisphere plays a more important role in language functioning than was previously thought, the study also attempted to investigate one of the critical linguistic variables (concreteness) that now supports this conjecture. Several secondary issues were also explored, including whether the number of syllables has a differential effect on the pattern of laterality.

Lateralization of English in English Monolinguals

In Experiment 1, a set of concrete and abstract English nouns were unilaterally presented to English monolinguals, who were asked to decide if the words were concrete or abstract. Response latency was measured to assess the degree of each cerebral hemisphere's capability in processing linguistic stimuli.

A strong RVF-LH superiority in word recognition performance was observed with latency averaging 41 msec faster for RVF presentation. The RVF-LH advantage is consistent with the traditional LH superiority in a variety of tasks involving linguistic processing of English words, including identification, naming, lexical decision and other semantic tasks. The results of Experiment 1 confirmed previous studies (Bradshaw, Gates, & Nettleton, 1972; Leiber, 1976). Demonstration of the strong RVF-LH advantage helps establish the validity of the experimental paradigm for both experiments as well as provide a basis of comparison between the English monolinguals of Experiment 1 and the Korean bilinguals of Experiment 2.

Concrete words were recognized faster than abstract words, although the difference disappeared with repetition of the words. There was a trend toward a smaller VHF effect for concrete than for abstract words. Although not reaching significance, the reduced VHF effect for concrete words was observed in all four blocks, including Block 4, where no main effect of concreteness remained. The trend is consistent with previous findings of a subtle difference in how the hemispheres process abstract and concrete words, and has been interpreted as an evidence of more direct involvement of the right hemisphere, at least for the recognition of simple, high-frequency nouns.

As reviewed in Chapters 1 and 2, there have been several reports of greater left-right asymmetry for abstract or nonimageable nouns than for concrete or imageable ones (Day, 1977, 1979; Ellis & Sheperd, 1974; Hines, 1976, 1977). However, others have been unsuccessful in demonstrating any evidence of smaller laterality for concrete words as compared to abstract words (Bradshaw & Gate, 1978; Bradshaw, Nettleton & Taylor, 1981; Saffran, Bogyo, Schwartz, & Marin, 1980). One interesting study, done by Warrington (1981), showed that a (single) patient was specifically unable to read concrete words, even though the patient had a left hemisphere lesion and a phonological impairment otherwise similar to that of deep dyslexics. The interaction of word concreteness and VHF, while not consistently found, appears often enough to warrant continued study.

Lateral Asymmetry for Korean Bilinguals

In Experiment 2, English, Hangul, and Chinese versions of the same words were unilaterally presented to the left or right visual fields of Korean subjects, who decided if the words were concrete or abstract. Response latency was recorded to examine if scriptual and language differences could alter the pattern of cerebral lateralization.

The data presented in Chapter IV confirmed the major prediction that phonetic scripts (Hangul and English) would show a RVF-LH advantage and an ideographic script (Chinese) would show a LVF-RH superiority in word recognition latency. Secondly, the interaction between VHF and number of syllables did not reach significance for either Chinese or Hangul. Although the double-syllable words in Chinese were significantly slower in response times, there was no evidence of syllable effect in Hangul. Third, the RVF-LH advantage was significantly smaller for concrete words for both Hangul and English and marginally smaller for Chinese. Finally, these results did not depend on the order of script type.

Most experiments demonstrating a left hemisphere advantage for linguistic tasks have used phonetic scripts. The question arose about whether similar effects would be found for non-phonetic ideographic scripts. Early studies (see Tzeng, Hung, & Garro, 1978 for review) did sometimes show contrasting laterality patterns with a LVF-RH superiority for ideographic script as opposed to RVF-LH superiority for phonetic script. But these experimental results were far from universal, with a number of inconsistent findings within the studies of ideographic script itself (Hatta, 1977; Sasanuma, 1975; Zhang & Yang, 1986). It was argued that these inconsistencies were due to a variety of potential confounds (see Chapter II) which were controlled in the present study.

The finding of a strong reversal of lateral asymmetry between phonetic and ideographic script for Korean subjects is consistent with the hypotheses that processing of different scripts might be lateralized in different hemispheres. The first hypothesis predicted that both Hangul and English would show a RVF-LH superiority in word recognition due to the left hemisphere's specialization of phonological processing. The latency data confirmed that despite tremendous orthographic differences and also potential morphological and semantic differences between the two scripts (English and Hangul), there was a clear advantage of RVF-LH for both.

The LVF-RH advantage for Chinese script is consistent with those clinical and experimental studies of both Japanese and Chinese subjects that show RH specialization for ideographic scripts. Hatta (1978, Exp.1), for example, found a RVF-LH advantage for naming kana words of different length with the proportion of errors as a dependent measure (response latencies were not reported). In his Stroop-effect test, Hatta (1981) showed a significant interference effect for kanji but failed to do so with kana color words. Specifically, when subjects were presented with kanji Stroop stimuli, there was a greater interference effect with their left than right visual field presentation. This again indicates a right hemisphere's specialization for kanji processing.

Tzeng et al. (1978) presented two types of single-syllable Chinese words were presented to Chinese subjects: phonograms, which contain a phonetic component as a clue to the pronunciation of the characters, and pictograms, which are pictographic in their origins and contain no internal phonetic cues. The LVF-RH effect was obtained regardless of the type of words. Apparently, the ideographic nature of Chinese orthography dominated any LH advantage for the phonetic cues.

Another important question was how the number of syllables or characters in a word affect the respective lateral advantages. The latency data showed that for Chinese script, single-syllable words were significantly faster than double-syllable ones. However, the number of syllables did not interact with the effect of visual half field. This finding rejects the third hypothesis which had predicted that for Chinese script, single-syllable words will be recognized faster at LVF while double-syllable words will be recognized faster at RVF. For Hangul, there was no sign of syllable effect or interaction between syllable and VHF.

However, Hatta (1978, Exp.2) and Tzeng et al. (1979) both found a RVF-LH advantage for double-syllable kanji or Chinese words using a naming task. In another naming task experiment, Sasanuma et al. (1977) found no evidence of asymmetry for two character nonwords consisting of two bona fide characters combined to form a nonexistent compound. There could be many reasons for the discrepancy in VHF effect between the present study and those other studies described above. But the prominent difference between the two is the task required to subjects. The present experiment used a type of semantic decision task while all of the above studies have adopted naming studies. It is generally accepted that the naming task favors the left hemisphere due to its proficiency in phonological processing and also superior control of speech output.

Though limited, there is some data on "character" effects in kana script. Hirata and Osaka (1967, Exp.1) found no visual half field difference for single character identification study using a naming task. In the same study, there was a RVF-LH advantage for two-character kana transciptions of words. Hatta (1978, Exp.1) also found a RVF-LH superiority for naming kana transcriptions of kanji words. But due to the intrinsic nature of Japanese writing system, he was not able to control the number of kana characters in their transcriptions and subsequently didn't examine how one-character versus three-character kana words affected cerebral laterality. So far there are no studies investigating laterality patterns for the identification of words that are normally written in kana (Paradis et al., 1985).

For the comparison between kana and Hangul, it should be mentioned that kana syllables are arranged left-to-right like most alphabetic languages while in Hangul, syllables are configured in a left-right-bottom order. Therefore it is not completely appropriate to compare "syllable" effects between kana and Hangul. The lack of a main effect of number of syllables implies that the nature of syllable in Hangul is somewhat different from that of kanji and more similar to English.

Concreteness and Laterality

The latency data for all three scripts showed a robust word concreteness effect, as did the data of the first experiment. The size of the effect of this independent variable was so convincing that no detailed discussion of the main effect seems to be necessary. Of more importance is the interaction between concreteness and VHF. A strong interaction effect for both Hangul and English showed greater RVF-LVF differences in latency for abstract words and reduced differences for concrete words. This pattern suggests a possibility of more right hemisphere involvement in processing concrete words.

Although the size of the effect appeared smaller than for two phonetic scripts, Chinese condition also showed a marginal concreteness x VHF interaction, and the direction was similar with the other two scripts, with a reduced LVF-RH advantage for concrete words. But this result should not be treated as equivalent with the same findings of either Hangul or English. Given the idea that Chinese will show the reverse pattern of cerebral laterality as compared to the phonetic scripts, we could have expected an interaction in a different direction, with a smaller VHF asymmetry for abstract words than for concrete words.

Suppose that the interaction of VHF and concreteness with phonetic scripts is given the usual interpretation, i.e., that the RH has a lexicon for concrete but not abstract words. If this were true, then the advantage in processing the spatial, ideographic forms of the Chinese versions of these words should be weighed against the need to go to the LH for access of abstract, but not concrete words, at the next stage of processing. This should produce (a) smaller VHF asymmetries for Chinese words overall, since on average the orthographic advantage is reduced by the lexical disadvantage, and (b) a smaller asymmetry for the abstract words. This was clearly disconfirmed by the data.

There are a number of theoretical alternatives that could be offered. First, it may be that the lexical entries are specific to orthographies, and that the Chinese versions of abstract and concrete words are lateralized differently. This may be true, but it seems to greatly comlicate the question of lexical organization, and is a relatively ad-hoc explanation of the data. Another possibility is that the abstract/concrete distinction has little to do with imageability of referents and more to do with the semantic comprehensibility of the terms. Still, it remains unclear why whatever LH specialization that produces an enhanced VHF effect for abstract words in phonetic scripts would not produce a reduced one for the ideographic scripts.

Laterality Effects in English for English vs. Korean Subjects

Although statistical comparisons may not be appropriate due to the differences in subjects's linguistic backgrounds, especially the way they acquired English (formal for Korean vs. informal for American subjects), and other more directly related factors such as the number of items and repetitions in two experiments, the similarity in data for English between the English and Korean groups should be pointed out.

Overall, the concreteness, VHF and VHF x concreteenss effects are quite similar for two groups. The main difference was that VHF x concreteness effect was greater among Koreans than among English subjects. This suggests a similar process of English in under this type of task (a semantic task), in spite of the relatively late acquisition of English among Koreans, and the presence of both another language and a script (Chinese) which is not read phonetically.

Limits and Future Directions

The similarity of laterality between Korean and Japanese (in some studies), despite significant discrepancy in linguistic and paralinguistic practice of two different groups, tells us that two ethnic groups might retain similar types of processing strategies at least for the recognition of highly familiar, high-frequency words. Future research on different level of linguistic behavior (e.g., sentence comprehension) is warranted to support this conjecture. But until then, we are still at a very speculative level due to the lack of establishment of a reliable database, particularly for Hangul processing.

The clear pattern of laterality for Korean biscriptuals suggests that more ethnic groups other than Japanese, if available, should be considered for investigating cerebral laterality. Researchers have faced great difficulties in controlling many variables in Japanese study, as reviewed above. By using Korean subjects, many of these concerns are not pertinent to Hangul. Further studies of reading Hangul will surely be a fruitful approach.

Although the item analyses showed that the results are not unique to the small set of stimuli used, it would be still preferrable to adopt a larger set of items. In doing that, it is also necessary to place a stringent controlling process for many of the noted variables (e.g., subject variables, stimuli variables, testing variables) to obtain reliable pattern of cerebral laterality. For example, in biscriptual study, many clinical differential results between performance for kana and kanji are interpreted as showing a difference of processing for reading a syllabic as opposed to an ideographic script as though all factors other than syllabicity versus ideographicity were equal or controlled for when, in fact, they are not. Perhaps a better approach would involve the use of regression analysis where subjects and materials factors are free to vary more naturally.

The present study only manipulated characteristics of stimuli. It is recommended that one should examine the performance of subjects on more than one task, which could highlight the specialized function of each of the two hemispheres in within-subject design. This type of manipulation will hopefully provide more consistent laterality patterns. Comparisons across groups, tasks and materials at once have contributed as much chaos as enlightenment in the area of cerebral lateralization in linguistic functioning.

Finally, more theoretical work is needed to better specify how different stages of processing, especially orthographic and lexical, are distributed and coordinated between the hemispheres.

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Young Sun will be teaching at his Alma Mater in Taegu, Korea where he spent most of his life. He will cherish his memories of his stay in Florida, and he will miss the friends he left behind.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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